

## CLAIMS

1 1. A method for detecting incidents along a roadway comprising the unordered steps  
2 of:  
3 arranging a plurality of readers at intervals along a roadway for reading  
4 uniquely identified data from each of a plurality of vehicles;  
5 correlating the data with previously read data to obtain information on each of the  
6 plurality of vehicles;  
7 determining the number of vehicles potentially affected by incidents along the  
8 roadway; and  
9 comparing the number of vehicles potentially affected by incidents to a sample  
10 threshold.

1 2. The method of claim 1, wherein the plurality of readers comprises a plurality of  
2 traffic probe readers.

1 3. The method of claim 1, wherein each of the plurality of readers is spaced at least  
2 five kilometers from an adjacent reader.

1 4. The method of claim 1, wherein the information is at least one of:  
2 a vehicle speed;  
3 an expected vehicle travel time between two adjacent readers; and  
4 an expected arrival time of each of the plurality of vehicles at one of the plurality  
5 of readers.

1 5. The method of claim 1, wherein the step of determining the number of vehicles  
2 potentially affected by an incident further comprises the step of determining the expected  
3 time for each of the plurality of vehicles to be detected by a particular one of the plurality  
4 of readers.

1 6. The method of claim 5, wherein the step of determining the number of vehicles

2 potentially affected by an incident further comprises the steps of:

3       determining the amount of time each vehicle time is overdue past the expected  
4 detection time; and

5       comparing an amount of time each vehicle time is overdue to a predetermined  
6 threshold.

1 7.       The method of claim 6, wherein the predetermined threshold is adjusted according  
2 to the roadway usage.

1 8.       The method of claim 5, wherein the step of determining the number of each of the  
2 plurality of vehicles potentially affected by an incident further comprises the steps of:

3       determining the amount of time each vehicle time is earlier than the expected  
4 detection time; and

5       comparing an amount of time each vehicle time arrived early to a predetermined  
6 threshold.

1 9.       The method of claim 8, wherein the predetermined threshold is adjusted according  
2 to the roadway usage.

1 10.      The method of claim 1, further comprising detecting an incident in response to the  
2 number of each of the plurality of vehicles potentially affected by an incident exceeding  
3 the predetermined sample threshold.

1 11.      The method of claim 10, wherein each of the plurality of vehicles potentially  
2 affected by an incident is overdue at one of the plurality of readers.

1 12.      The method of claim 10, wherein each of the plurality of vehicles potentially  
2 affected by an incident has arrived early at one of the plurality of readers.

1 13.      The method of claim 12, wherein the number of each of the plurality of vehicles  
2 potentially affected by an incident is counted over a predetermined interval.

1 14. The method of claim 4, wherein the arrival time of expected readings is a function  
2 of the vehicle type.

1 15. The method of claim 1, wherein the plurality of readers comprises a transponder  
2 reader.

1 16. The method of claim 1, wherein the plurality of readers comprises a license plate  
2 reader.

1 17. The method of claim 1 wherein an instantaneous speed of each of the plurality of  
2 vehicles is determined by a Toll Gateway sensor.

1 18. The method of claim 6, wherein the expected time for each of the plurality of  
2 vehicles to be detected by reader is calculated by:

$$\text{ExpSpeed}[V_i, S_j] = \min(\text{StartSpeed}[V_i, S_j], \text{HighSpeed}[S_j])$$

$$\text{ExpTime}[V_i, S_j] = \frac{\text{Length}[S_j]}{\text{ExpSpeed}[V_i, S_j]}$$

5 where,

6  $V_i$  is a vehicle entering a road segment  $S_j$ ;

7  $\text{ExpTime}[V_i, S_j]$  = expected time for  $V_i$  to be detected;

8  $\text{StartSpeed}[V_i, S_j]$  = starting speed of  $V_i$  at the beginning of segment  $S_j$ ;

9  $\text{ExpSpeed}[V_i, S_j]$  = expected speed over segment  $S_j$ ;

10  $\text{HighSpeed}[S_j]$  = average legal speed limit over the segment starting at  $S_j$ ;

11 and

12  $\text{Length}[S_j]$  = length of the segment starting at  $S_j$ .

1 19. The method of claim 18, wherein an overdue time for each of the plurality of vehicles  
2 that has not been detected by the expected reader within the expected time, is calculated by:

$$\text{Overdue}[V_i, S_j, t_c] = \frac{t_c - \text{StartTime}[V_i, S_j] - \text{ExpTime}[V_i, S_j]}{\text{ExpTime}[V_i, S_j]} \times 100\%$$

4 where,

5  $StartTime[V_i, S_j]$  = time that  $V_i$  entered the segment starting at  $S_j$ .

1 20. The method of claim 18, wherein a difference between the expected and actual  
2 link travel time for each of the plurality of vehicles is calculated by:

$$Diff[V_i, S_j] = \frac{\max\left(ActualTime[V_i, S_j], \frac{Length[S_j]}{HighSpeed[S_j]}\right) - ExpTime[V_i, S_j]}{ExpTime[V_i, S_j]} \times 100\%$$

3  
4 where:

5  $ActualTime[V_j, S_j]$  = actual time for  $V_i$  to travel over segment  $S_j$ .

1 21. The method of claim 18, wherein the starting speed of  $V_i$  is calculated by:

2  $StartSpeed[V_j, S_j]$  = average speed of  $V_i$  over a prior segment.

1 22. The method of claim 18, wherein the starting speed of  $V_i$  is calculated by:

2  $StartSpeed[V_j, S_j]$  = instantaneous speed of  $V_i$  at the start of  $S_j$  measured by a toll  
3 gateway speed sensor.

1 23. The method of claim 1, further comprising the step of declaring an incident in  
2 response to the number of each of the plurality of vehicles potentially affected by  
3 incidents being greater than the sample threshold.

1 24. The method of claim 1, further comprising the step of excluding each vehicle, that  
2 is overdue for more than a predetermined cutoff threshold measured from the time that  
3 the vehicle is initially overdue, from being counted in the number of each of the plurality  
4 of vehicles potentially affected by incidents.

1 25. The method of claim 1, further comprising the step of excluding each vehicle, that  
2 has arrived early at the end of a roadway segment for more than a predetermined cutoff  
3 threshold measured from the time that the vehicle is initially early, from being counted in  
4 the number of each of the plurality of vehicles potentially affected by incidents.

1 26. The method of claim 1, further comprising the step of suppressing the detection of  
2 an incident in a roadway segment where the number of vehicles exiting the segment of  
3 the roadway on an off-ramp over a predetermined interval of time exceeds a  
4 predetermined threshold.

1 27. A method for detecting incidents along a roadway comprising the unordered steps  
2 of:  
3 arranging a plurality of traffic probe readers at intervals along a roadway for  
4 reading a transponder disposed on a vehicle;  
5 correlating the transponder readings from each of the plurality of vehicles and  
6 expected readings from each of the plurality of vehicles at more than one traffic probe  
7 reader; and  
8 detecting incidents which result in an interruption to the flow of traffic.

1 28. The method of claim 27, further comprising the step of writing time and location  
2 data into the transponder of each of the plurality of vehicles.

1 29. The method of claim 27, further comprising the step of arranging a plurality of  
2 toll gateways at intervals along a roadway for reading a transponder ID disposed on each  
3 of a plurality of vehicles and for determining the presence of vehicles not having a  
4 transponder ID.

1 30. An incident detection system comprising:  
2 a traffic management center processor connected to a data network;  
3 a plurality of unique vehicle data readers connected to said data network such that  
4 uniquely identified data are read from each of a plurality of vehicles;  
5 a correlation processor, wherein said uniquely identified data are correlated to  
6 obtain a count of overdue vehicles and early arriving vehicles; and  
7 an incident detection processor.

1 31. The system of claim 30 wherein said plurality of unique vehicle data readers  
2 further comprise:  
3 a plurality of traffic probe readers, each of said plurality of traffic probe readers  
4 having an automatic vehicle identification reader; and  
5 a plurality of toll gateways, each of said plurality of toll gateways having an  
6 automatic vehicle identification reader.

1 32. The system of claim 30 further comprising a plurality of roadside toll collection  
2 devices coupled to said plurality of toll gateways, said plurality of traffic probe readers,  
3 and said traffic management center, such that the volume of data transmitted to said  
4 traffic management center is minimized.

1 33. The system of claim 30 wherein said correlation processor is connected to said  
2 traffic management center processor.

1 34. The system of claim 30 wherein said correlation processor is connected to said  
2 roadside toll collection device.

1 35. The system of claim 30 wherein said incident processor is connected to said  
2 traffic management center processor.

1 36. The system of claim 30 wherein said incident processor is connected to said  
2 roadside toll collection device.